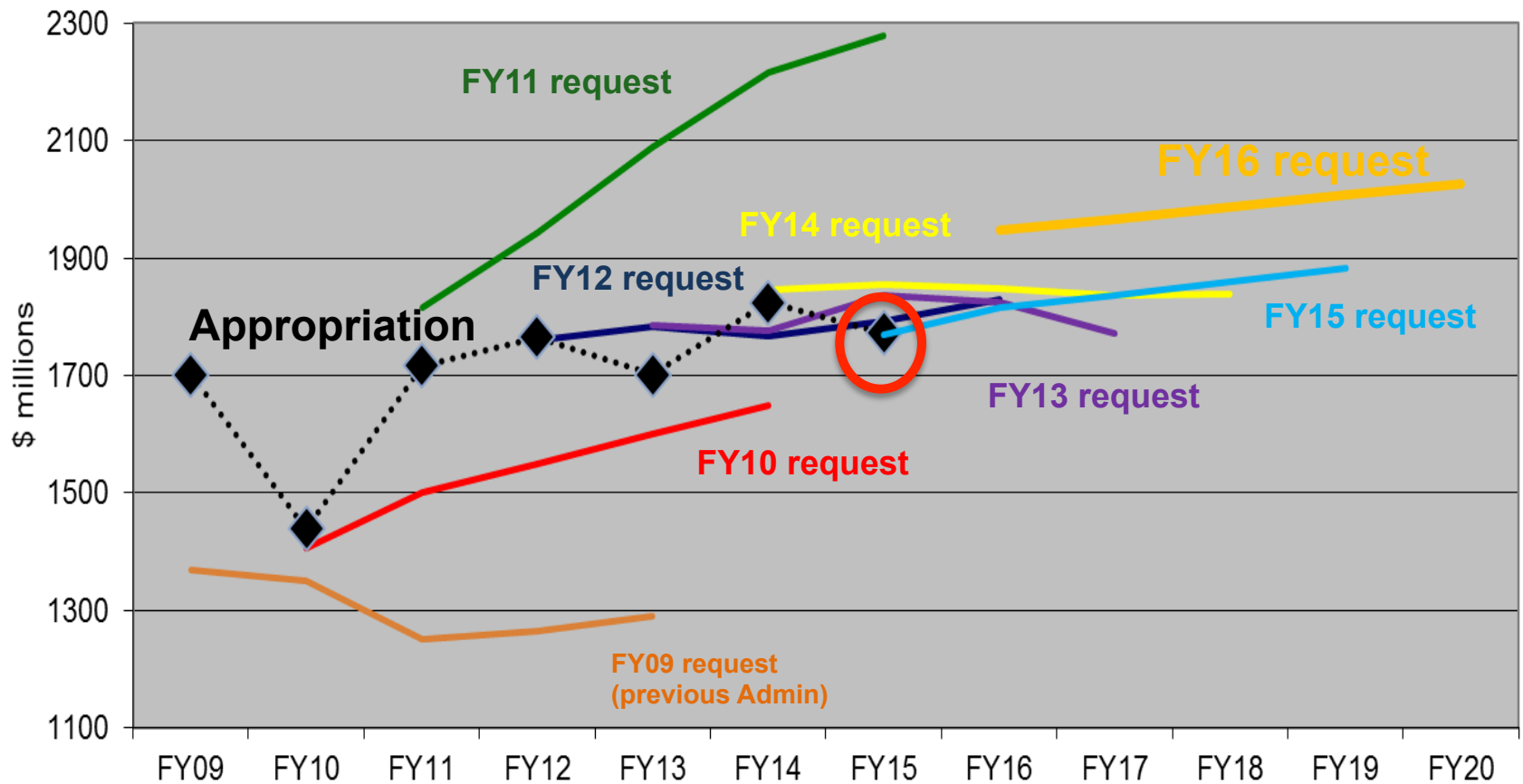


NASA HQ Atmos Comp Program Scientists

SEAC⁴RS Science Team Meeting

Pasadena, CA

28 April – 1 May 2015



Overall Budget Summary

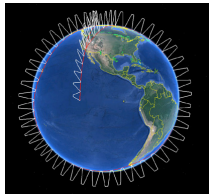


- ESD budget increases significantly

	<u>FY15</u>	<u>FY16</u>	<u>FY17</u>	<u>FY18</u>	<u>FY19</u>	<u>FY20</u>
FY16	1.730	1.894	1.913	1.932	1.952	1.971
FY15		1.762	1.784	1.805	1.829	---

- NASA now has mandate for additional long-term measurements for the nation:
 - Altimetry after Jason-3
 - Solar Irradiance, Ozone Profile, Earth Radiation Budget all starting in FY16
- Sustainable Land Imaging Program (w/USGS; NASA funds flight hardware):
 - TIR-FFD (2019)
 - Upgraded Landsat-9 (2023)
 - Focused technology development to inform designs of Landsat-10+
- Continued development and launch of: SAGE-III/ISS, ECOSTRESS/ISS, GEDI/ISS, CYGNSS, TEMPO, GRACE-FO, ICESat-2, SWOT, NISAR, PACE
- Continue Venture Class on schedule with full funding
- OCO-3 completion and flight to ISS in late 2017
- CLARREO Technology Demonstration instruments on ISS - development and flight in late 2019 (2 instruments, Reflected Solar/HySICS and IR Pathfinder)

Earth Venture Suborbital -2



Atmospheric Tomography Experiment (ATom) – Harvard University (Steve Wofsy)

This investigation will study the impact of human-produced air pollution on certain greenhouse gases and aerosols. Airborne instruments will look at how atmospheric chemistry is transformed by various air pollutants and at the impact on methane and ozone which affect climate. Flights aboard NASA's DC-8 will originate from the Armstrong Flight Research Center in Palmdale, California, fly north to the western Arctic, south to the South Pacific, east to the Atlantic, north to Greenland, and return to California across central North America.

North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) – Oregon State U. (Mike Behrenfeld)

This investigation will improve predictions of how ocean ecosystems would change with ocean warming. The mission will study the annual life cycle of phytoplankton and the impact small airborne particles derived from marine organisms have on climate in the North Atlantic. The large annual phytoplankton bloom in this region may influence the Earth's energy budget. Research flights by NASA's C-130 aircraft from Wallops Flight Facility, Virginia, will be coordinated with a University-National Oceanographic Laboratory System (UNOLS) research vessel.

Atmospheric Carbon and Transport – America – Penn State University (Kenneth Davis)

This investigation will quantify the sources of regional carbon dioxide, methane and other gases, and document how weather systems transport these gases in the atmosphere. The research goal is to improve identification and predictions of carbon dioxide and methane sources and sinks using spaceborne, airborne and ground-based data over the eastern United States. Research flights will use NASA's C-130 from Wallops and the UC-12 from Langley Research Center in Hampton, Virginia.

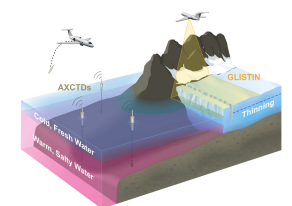
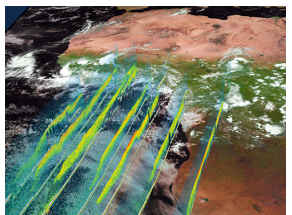
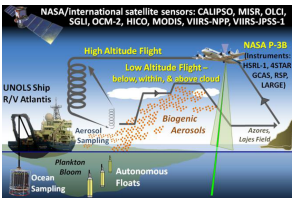
ObseRvations of Aerosols Above Clouds and Their IntEractionS (ORACLES) – ARC (Jens Redemann)

ORACLES will probe how smoke particles from massive biomass burning in Africa influences cloud cover over the Atlantic. Particles from this seasonal burning that are lofted into the mid-troposphere and transported westward over the southeast Atlantic interact with permanent stratocumulus "climate radiators," which are critical to the regional and global climate system. NASA aircraft, including a Wallops P-3 and an Armstrong ER-2, will be used to conduct the investigation flying out of Walvis Bay, Namibia.

Oceans Melting Greenland (OMG) – JPL (Josh Willis)

The objective of OMG is to investigate the role of warmer saltier Atlantic subsurface waters in Greenland glacier melting. The study will help pave the way for improved estimates of future sea level rise by observing changes in glacier melting where ice contacts seawater. Measurements of the ocean bottom as well as seawater properties around Greenland will be taken from ships and the air using several aircraft including a NASA S-3 from Glenn Research Center in Cleveland, Ohio, and Gulfstream III from Armstrong.

***Note: EV-1: ATTREX and DISCOVER-AQ are wrapping up**



Planned ROSES 16 ACFA Solicitations



- KORUS-AQ
- CAMPE_x
- UARP Core Support
- Aura Science Team
- ACMAP

Clouds-Aerosol Monsoon Philippines Experiment (CAMPEX)



solicitation 2016; campaign summer 2018

Science Questions

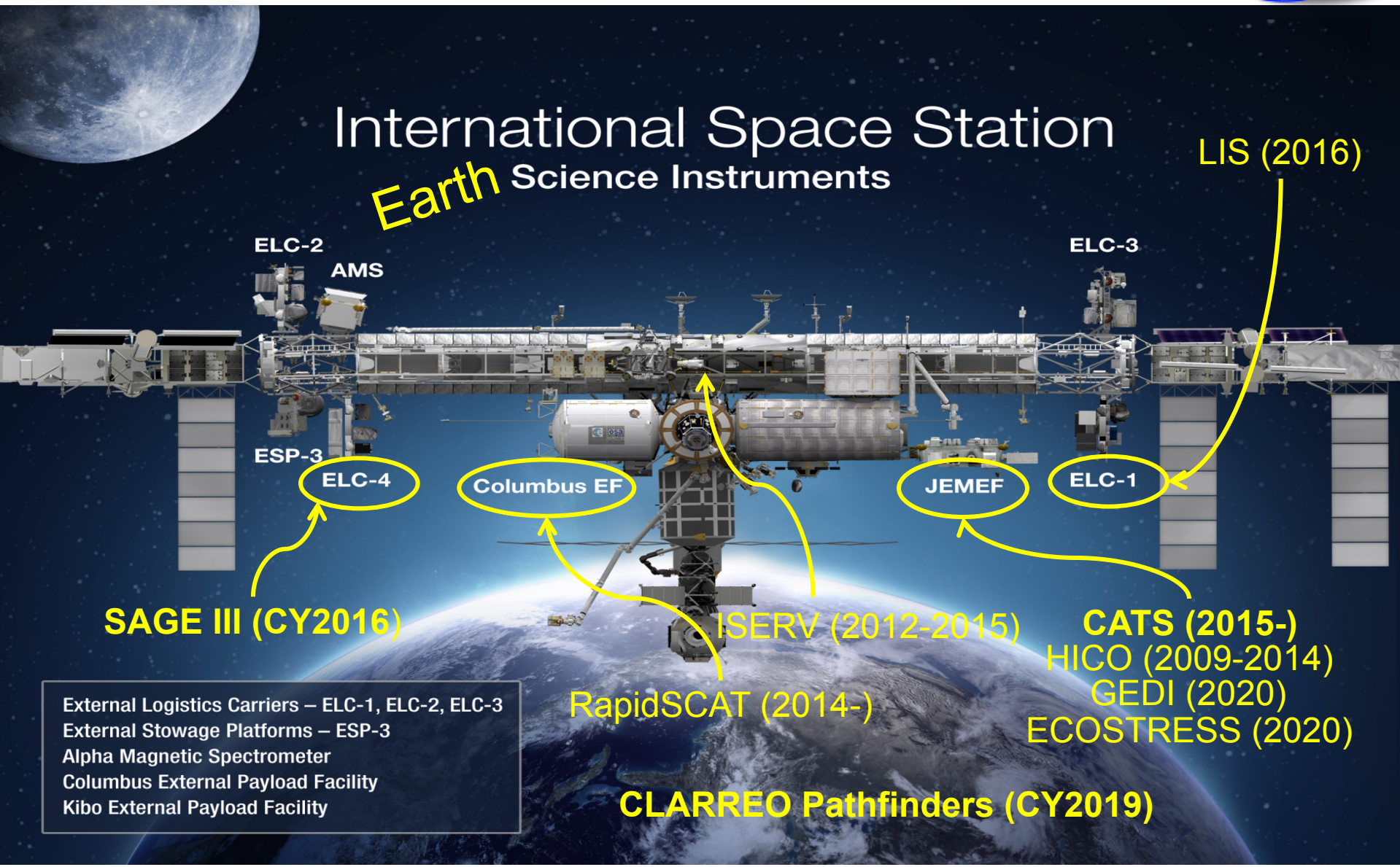
- To what extent are aerosol particles responsible for modulating warm and mixed phase precipitation in tropical environments?
- To what extent do aerosol induced changes in clouds and precipitation feedback into aerosol lifecycle?
- How does the aerosol and cloud influence on radiation co-vary and interact?
- How does land use change factor into cloud and precipitation change? Is land use change a confounder for aerosol impacts?



New Missions & Missions in Development



International Space Station *Earth* Science Instruments



External Logistics Carriers – ELC-1, ELC-2, ELC-3
External Stowage Platforms – ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

Missions in Development - PACE



Pre-Aerosol, Cloud, and ocean Ecosystem (PACE) is an ocean color, aerosol, and cloud mission identified in the 2010 report “Responding to the Challenge of Climate and Environmental Change: NASA’s Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space Science”.

Science Objectives

- **Primary:** Understand and quantify global ocean biogeochemical cycling and ecosystem function in response to anthropogenic and natural environmental variability and change: **ocean color sensor**
- Extend key Earth system data records on global ocean ecology, biogeochemistry, clouds, and aerosols (expanded ocean color sensor similar to MODIS)
- **Secondary:** Understand and resolve/quantify the role of aerosols and clouds in physical climate (the largest uncertainty): **polarimeter**

Risk	• 8705.4 Payload Risk Class C
Launch	• 2022/2023, budget and profile driven
Orbit	• 97° inclination; ~650 km altitude; sun synchronous
Duration	• 3 years
Payload	• Ocean color instrument; potential for a polarimeter
LCC	• \$805M Cost Cap

Next Decadal Survey – Early 2017



Realities:

- Decadal Survey recommendations are not binding
 - Given the importance of earth observations from space, the administration and congress have influence as well
 - NASA ESD has been directed to to implement sustained measurements in support of NOAA and USGS; the direction is somewhat ambiguous.
- ESD budget will likely not increase substantially, a decrease is possible.
- Satellite mission costs and schedules are predefined/controlled in a “capped” program (e.g., EVI & EVM)
- Directed missions to NASA centers are essential to the agency, however, it may be possible to cost cap a directed mission
- Earth Venture is now an integral part of ESD
- Named-mission backlog from 1st Decadal Survey is substantial

Desired Inputs from Decadal Survey



Contents:

- Recommend balance between Flight and non-Flight
- Recommend balance between R&A, Applied Science, and Technology development (and support activities: aircraft, data centers, high performance computing)
- Recommend balance between systematic/directed and openly competed missions
 - Maximum mission cost?
 - Add EVM or EVI with different cost caps?
 - Coordinated flying policy?
- Recommend range of mission architectures
 - Common spacecraft
 - Small sats?
- Recommend balance between new measurements and continuing time series
 - No R2O
 - How to account for international missions?
- Address named missions from 1st Decadal Survey

TEMPO - Tropospheric Emissions: Measurement of Pollution



PI: Kelly Chance, Smithsonian Astrophysical Observatory

Instrument Development: Ball Aerospace

Project Management: NASA LaRC

Selected Nov. 2012 as NASA's first Earth Venture Instrument

- Instrument **delivery September 2017**
- NASA will arrange hosting on commercial geostationary communications satellite

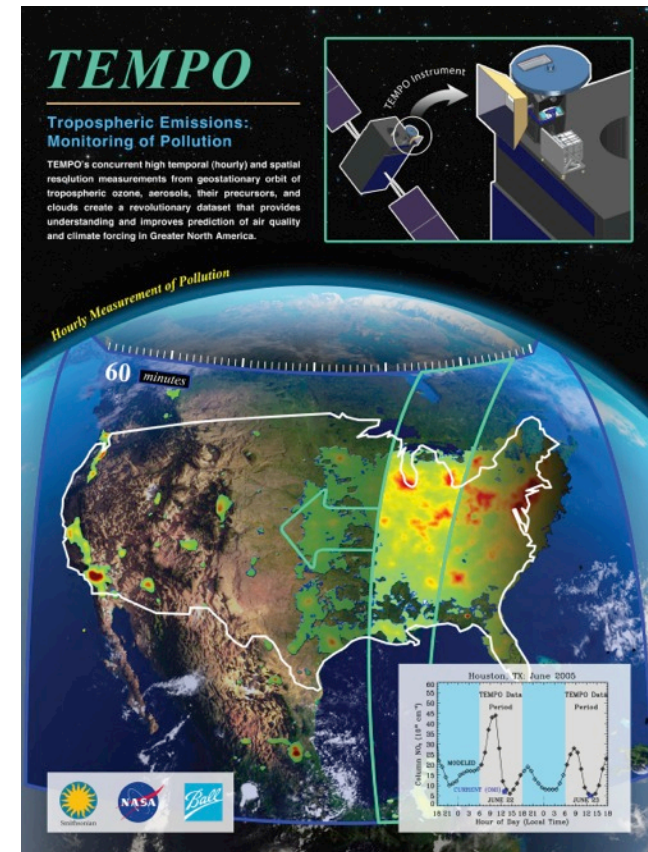
Provides hourly daylight observations to capture rapidly varying emissions & chemistry important for air quality

- Ultraviolet - Visible grating spectrometer to measure key elements in tropospheric ozone and aerosol pollution
- Exploits extensive measurement heritage from LEO missions
- Distinguishes boundary layer from free tropospheric & stratospheric ozone

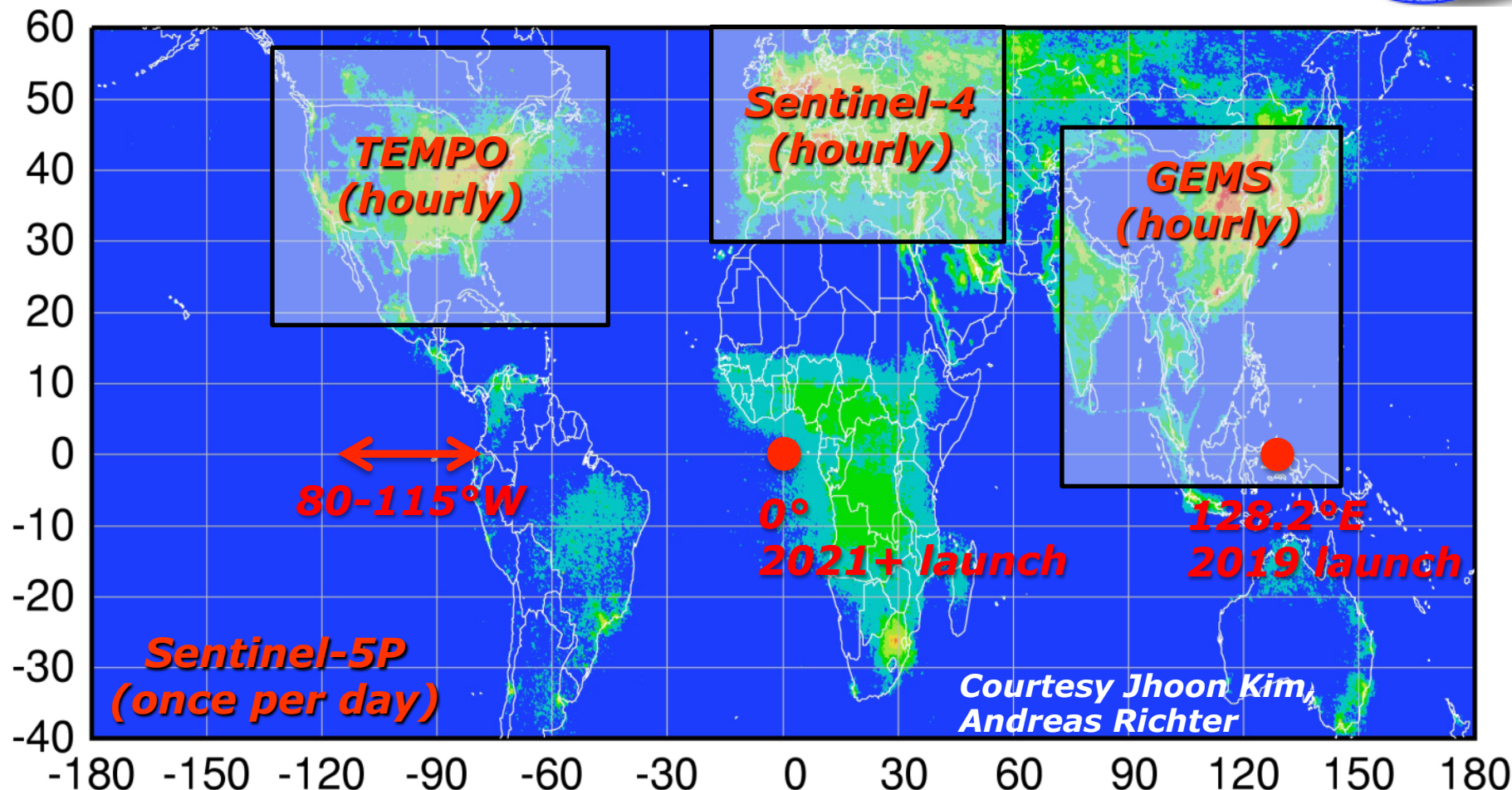
Aligned with National Research Council “Earth Science Decadal Survey” recommendations

- Makes many of the atmosphere measurements for the NASA GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission (<http://geo-cape.larc.nasa.gov>)
- Responds to the phased implementation recommendation of GEO-CAPE mission design team

North American component of an international constellation for air quality observations



Global pollution monitoring constellation: Tropospheric chemistry missions funded for launch 2016-2021



Policy-relevant science and environmental services enabled by common observations

- Improved emissions, at common confidence levels, over industrialized Northern Hemisphere
- Improved air quality forecasts and assimilation systems
- Improved assessment, e.g., observations to support United Nations Convention on Long Range Transboundary Air Pollution

Korea-US Air Quality Study (KORUS-AQ) 2016



What:

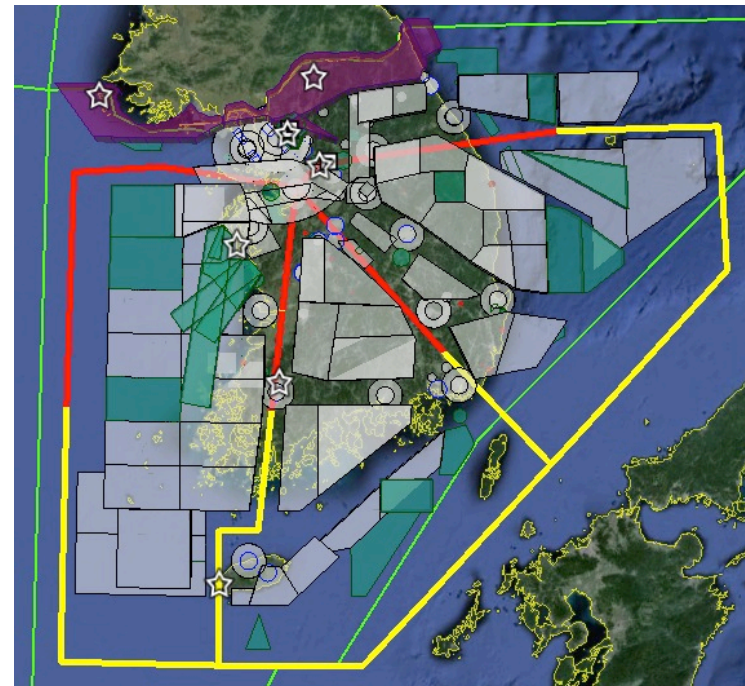
- A co-operative intensive airborne, ground, and satellite field study being planned for a 6-week period within April-June 2016
- Focus on Korean peninsula and adjacent waters

Why:

- Readiness for geostationary satellite observability of air quality – trace gases and aerosols
- Megacity pollution – Model evaluation of Emissions, Chemistry, Transport
- Anthropogenic/Biogenic Mixtures
- Transboundary pollution
- Capacity building

Components:

- NASA DC-8 flying laboratory
- Korean partner aircraft
- Ground sites including the Korean Air Quality network and research supersites



Notional flight planning map illustrating the feasibility of conducting intensive airborne air quality surveys in Korea

Participants:

- Korea Ministry of Environment, National Institute of Environmental Research, and Universities
- US NASA, NCAR, Universities, and possible other government agencies

Korea-US Air Quality Study (KORUS-AQ) 2016



- International Agreement draft in review at Dept of State
- Bilateral Working Group for science & implementation planning:
 - US lead is Jim Crawford, NASA LaRC, james.h.crawford@nasa.gov
- US and Korean White Papers available at:
https://espo.nasa.gov/home/korus-aq/content/KORUS-AQ_Science_Overview_0
- Open solicitation:
 - ROSES-2015, Appendix A.19
 - Proposal deadline is 15 May
 - POC is Hal Maring, hal.maring@nasa.gov



Questions?